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# Tacit Driving Knowledge, Emotional Intelligence, Stressful Events and Accident Risk: Traffic Safety Implications

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We developed two tacit driving knowledge scales to investigate whether safer drivers can more accurately assess risks associated with a variety of driving conditions including road hazards and the driver's internal or emotional state. The tests were administered with a battery of conventional cognitive tests, personality instruments and situational variables chosen to predict accident involvement. The correlations between the tacit driving knowledge measures and the accident criteria ranged up to .22 ($p < .001$), and compared favorably to correlations between the accident criteria and the conventional measures. Odds ratios for the tacit driving knowledge tests show that low and average scoring participants had 5 and 2.3 times as many at-fault accidents as high scoring individuals. The data also indicate that stress, fatigue and illness elevate accident risk. The analyses demonstrate the importance of emotional and tacit knowledge and provide specific recommendations to improve driver safety.

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Tacit Driving Knowledge, Emotional Intelligence, Stressful Events and Accident Risk:

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# TACIT DRIVING KNOWLEDGE, EMOTIONAL INTELLIGENCE, STRESSFUL EVENTS AND ACCIDENT RISK: TRAFFIC SAFETY IMPLICATIONS

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## Abstract

We developed two tacit driving knowledge scales to investigate whether safer drivers can more accurately assess risks associated with a variety of driving conditions including road hazards and the driver's internal or emotional state. The tests were administered with a battery of conventional cognitive tests, personality instruments and situational variables chosen to predict accident involvement. The correlations between the tacit driving knowledge measures and the accident criteria ranged up to .22 ($p<.001$), and compared favorably to correlations between the accident criteria and the conventional measures. Odds ratios for the tacit driving knowledge tests show that low and average scoring participants had 5 and 2.3 times as many at-fault accidents as high scoring individuals. The data also indicate that stress, fatigue and illness elevate accident risk. The analyses demonstrate the importance of emotional and tacit knowledge and provide specific recommendations to improve driver safety.

Tacit Driving Knowledge, Emotional Intelligence, Stressful Events and Accident Risk:

Traffic Safety Implications

Two tacit driving knowledge tests were constructed and scored using a consensus-based procedure that was developed to assess expertise across a variety of professional, social, academic and emotional domains (Sternberg & Wagner, 1993; Legree, 1995; Legree, Martin & Psotka, in press; Mayer, Caruso & Salovey, in press). The consensus-based procedure measures expertise by assessing tacit knowledge that is experiential or procedural in nature, and intimately or critically related to a field of expertise. We reasoned that accident involvement should correlate with some tacit knowledge domain because (1) accident risk decreases with driving experience and (2) driving constitutes a procedural activity that presumably results in the acquisition of tacit knowledge.

We also knew that novice and experienced drivers differ in their subjective assessments of risk (Trankle, Gelau & Metker, 1990) and that risk assessment has been characterized as a critical driving skill (Evans, 1993; Jonah, 1986). Therefore we reasoned that risk assessment is intimately related to accident involvement (or avoidance) and decided to develop two tacit knowledge tests corresponding to risk assessment. The tacit driving knowledge scales required participants to estimate either the appropriate safe speed given various driving conditions or the percentage of accidents involving various road hazards.

The tacit driving knowledge tests were based on the expectation that differences in the tacit knowledge of high versus low risk drivers would be evidenced by the precision with which individuals could estimate the danger associated with various road hazards and driving conditions. From both a risk management and a conventional wisdom perspective it seemed reasonable that a tendency to either over or underestimate the importance of road hazards would decrease an individual's ability to respond appropriately to adverse driving conditions. Therefore it was expected that high-risk individuals would over or underestimate the danger associated with driving hazards and/or road conditions. We hypothesized that individuals who provided poor (less accurate) estimates would be involved in more and worse accidents than those individuals who produced more optimal and accurate estimates.

The tacit driving knowledge scales contained a number of environmentally-oriented items that correspond to information that may be mentioned but is unlikely to be emphasized in driver education classes, e.g., the extent to which a driver should slow down in light rain. We believe that this type of knowledge is not usually or formally emphasized in driver education classes because it is difficult to present or to assess mastery of this knowledge given its imprecise nature. In fact, there were no formally correct answers to the test items we developed because the corresponding knowledge base had not been developed. Without a formal knowledge base to reference, much of this information appears to be opinion and presenting it as factual could result in unanticipated consequences. To continue the "light rain" example, consider the implications of criticizing a student who indicates that a driver should slow down excessively in light rain:

while an excessive decrease in speed can be properly criticized as inappropriate, an instructor may assume some liability for encouraging faster speeds in the unlikely event of an accident.

While most of the tacit knowledge test items referenced environmental hazards, some of the items focused on moderating driving speed or style in response to affective states or health considerations, e.g., stress due to family problems, or an illness such as a cold. The affective items were based on conceptualizations of emotional intelligence as encompassing abilities and knowledge that allow individuals to understand, control and respond appropriately to internal or emotional conditions (Mayer, Caruso & Salovey, in press).

Because our test items were based on theoretical developments in the fields of emotional intelligence and tacit knowledge, this study addresses the utility of these theoretical conceptualizations against life-threatening criteria, i.e., traffic accident involvement and severity. Each year traffic crashes result in economic costs of 150 billion dollars and over 40,000 fatalities (U.S. Department of Transportation, 1998a), and we expected that documenting the relationship between tacit emotional and environmental driving-knowledge and crash risk would provide practical insights to improve driver safety.

## Method

### Overview

A retrospective design was adopted to correlate the tacit driving knowledge measures and a number of conventional psychological and situational variables that had been empirically or theoretically related to accident involvement. We used U.S. Army Safety Center (USASC) records to identify accident-involved soldiers and compared those individuals to soldiers who had not appeared in the database. Criterion data were constructed by combining USASC accident data with self-report accident data we collected. This design allowed a comparison of the predictive power of the tacit knowledge scales and the conventional variables.

### Tacit Driving Knowledge Tests

The Safe Speed Knowledge Test presented a scenario requiring participants to assume that an individual was driving a safe car under optimal conditions. The participants were then required to indicate how much the individual should slow down to ensure safety given 14 separate conditions. The 14 conditions served as test items and required independent responses. Ten items referenced environmental factors (e.g., heavy traffic, snow or rain), three items referenced internal affective/health states (e.g., stress or illness), and one item referenced both an internal state and an environmental factor (i.e., anger and light rain).

The Accident Causation Test required individuals to estimate the percentage of major accidents that involved 14 conditions. These conditions referenced a variety of environmental factors, e.g., road condition and weather, as well as characteristics specific to the driver, e.g., age and stress. The two scales are presented in Figures 1 and 2. More attention and discussion will focus on the Safe Speed Knowledge Test because it provided more useful insights into traffic safety.

Assume someone is driving a safe car in light traffic under optimal/perfect conditions. Given the following considerations, please estimate how much that individual (driver) should or shouldn't slow down and change speed to ensure safety.

| CONDITIONS: | -20 MPH<br>Slow Down | -10MPH | 0 MPH<br>Same Speed |
|---|---|---|---|
| 1. Snow and heavy traffic | | | |
| 2. Clear weather and light traffic | | | |
| 3. Snow and no traffic | | | |
| 4. Dry roads at midnight | | | |
| 5. Stressed driver due to problems at work | | | |
| 6. Moderately heavy traffic | | | |
| 7. Gravel and light traffic | | | |
| 8. Clear roads and somewhat breezy | | | |
| 9. Light rain and curvy roads | | | |
| 10. Angry and light rain | | | |
| 11. Light traffic and hilly terrain | | | |
| 12. Slightly worn tires | | | |
| 13. Upset with family over finances/money | | | |
| 14. Sick with a head cold | | | |
| | -20 MPH<br>Slow Down | -10MPH | 0 MPH<br>Same Speed |

Figure 1. Safe Speed Knowledge Test

Please mark the bubble to estimate the percentage of major accidents that involve the following conditions:

0% 50% 100%

1. Windy roads
2. Drunk drivers
3. Excessive speed
4. Interstate highways
5. Intersections at stop signs
6. Parking lots
7. Rainy conditions
8. Drivers between 25 & 55 years old
9. Emotionally stressed drivers
10. Sunny weather
11. Drivers between 20 & 25 years old
12. Snowy conditions
13. Drivers between 55 & 75 years old
14. Intersections at traffic lights

0% 50% 100%

Figure 2. Accident Causation Knowledge Test.

The consensual scaling method used to score the driving knowledge tests is dissimilar from those used to score most tests. The procedure is based on a difference score between an individual's rating and the mean rating for an item as calculated by averaging the responses of all the participants. The scoring procedure produces an interval datum for each item that represents

the distance between the subject's rating and the mean for that item, i.e., the distance equals the absolute value of the difference. Using this scoring procedure, better (more consensually correct) responses are indicated by lower values, and a distance of 0 indicates an optimum response.

However, correlations involving the tacit knowledge scales were "reflected" so that superior performance on these scales would correlate positively with superior performance on conventionally scored knowledge and aptitude scales. This reflection is equivalent to scoring the scales so that higher values indicate superior performance, e.g., by subtracting the distance scores from a constant.

Standard Psychological Measures

A number of measures that had been empirically or theoretically linked to accident involvement were assembled into a test battery and administered with the tacit driving knowledge tests. Correlational data for these variables provide a context to interpret the validities obtained for the tacit driving knowledge tests.

Stable Characteristics. Many of the standard psychological measures addressed stable or relatively stable characteristics that were primarily hypothesized to correlate with accident rate criteria (i.e., accidents/day, at-fault accidents/day, and total cost of accidents), as opposed to accident occurrence criteria (i.e., at-fault status given an accident, and cost/accident). The stable measures addressed characteristics such as general cognitive aptitude, spatial reasoning ability, channel capacity, personality traits and moving violation history.

General cognitive aptitude was assessed by the Armed Forces Qualification Test (AFQT), which is administered when soldiers enlist and measures acquired verbal and quantitative knowledge. The spatial reasoning and personality measures had been developed to predict job performance (Peterson et al., 1996; White & Young, 1998), and the channel capacity measure to select commercial drivers (Cantor, in press). Self-report items were included to estimate the number of moving violations (tickets) and to assess views on discipline and a number of other personality characteristics. The stable variables are referenced in Table 4.

Transient Characteristics. Self-report items were developed to address the possibility that transient or situational events might elevate accident risk for relatively short time periods. These items were incorporated into an accident report form designed to describe the conditions and events surrounding each accident reported by the participants. It was expected that transient events would be primarily related to accident occurrence criteria (e.g., who is at fault given an accident) as opposed to accident rate criteria (who has accidents). The items addressed the respondent's emotional or mental state immediately prior to the accident and queried for the presence of adverse environmental or physical conditions.

Items most closely related to one's emotional or mental state include fatigue, level of stress, having experienced a stressful life event (including divorce, illness, family death, marriage/engagement, birth, financial disaster, job loss), the presence of distracting passengers,

and the use of alcohol or medicine. The presence of adverse environmental or physical conditions was assessed by items pertaining to traffic, weather, road and vehicle conditions. The transient/situational variables are listed in Table 5.

It is important to recognize that some transient events may reflect stable characteristics. For example, although alcohol consumption may be temporally associated with accident involvement, it may also reflect alcoholism or an alcohol-oriented lifestyle (stable characteristics) and be associated with higher lifetime accident rates. However, other transient events do not seem to be closely associated with stable characteristics. For example, some stressful events (such as the death of a relative or a divorce) may result in elevated risk for a comparatively short time period while having little effect on long term accident risk.

## Accident Data

Accident data were obtained from two sources. First the U.S. Army Safety Center (USASC) database was used to locate accident data for the participants. Second, the participants completed a self-report accident survey to describe accidents in which they were involved during the previous five years. The self-report and USASC data were merged to produce criteria quantifying the:

(1) Total number of at-fault accidents per day,
(2) Total number of accidents per day,
(3) Total accident cost,
(4) Driver (respondent) fault given an accident
(5) Accident cost per crash.

Accident rates were computed for all participants, while cost and driver-fault data were only available for individuals who had been involved in accidents. The criteria quantified accident involvement, as opposed to accident avoidance, with accident involvement indicated by positive, e.g., high versus low accident rates or cost.

## Participants

Approximately one-third of the participants were obtained using USASC data to identify individuals who had been involved in traffic accidents. The remaining participants were matched on rank but had not been involved in accidents reported in the USASC database. A non-even split was adopted because we expected that many of the matched soldiers would provide self-report accident information not contained in the USASC database. A total of 400 soldiers were administered the tacit knowledge scales, test battery and accident survey. The tacit knowledge scales could not be administered to 151 additional subjects for whom we had test battery and accident survey data. Thus some of the standard measures and associated correlations reflect data collected from the total sample of 551 participants.

## Procedure

The data were collected between June and September of 1998 at five U.S. Army installations. Four hours were required to administer the test battery and the accident information survey. Individuals were first informed that participation was voluntary and were then requested to complete the test battery and the self-report accident description survey. The test battery contained the tacit driving knowledge scales and the stable psychological measures that had been related to accident involvement. The accident survey allowed participants to describe accidents in which they had been drivers during the previous five years; therefore the accident-related transient/situational information was collected for each accident, e.g., the presence of distracting passengers or inclement weather.

# Results

## Tacit Driving Knowledge Tests: Individual Difference Analyses

Initial Data Reduction. In the initial analyses, tacit driving knowledge test scores were computed as the mean of the 14 distance scores (absolute value of the difference) for each test. For these measures, reliability estimates of .80 and .64 were obtained respectively for the Safe Speed and Accident Causation Knowledge tests.

Correlations among the tacit driving knowledge scales, general cognitive aptitude and the accident criteria are presented in Table 1. As noted, we reflected correlations involving the tacit knowledge tests so superior performance on a tacit knowledge measure would correlate positively with superior performance on conventionally scored knowledge and aptitude tests. We did not reflect the accident criteria and therefore hypotheses involving the accident criteria and the knowledge or aptitude scales are supported by negative correlations.

The correlations between the overall tacit driving-knowledge test measures and the accident criteria are presented in the first section of Table 1. These values indicate that the Safe Speed Knowledge Test correlated significantly with several of the criteria used to quantify accident involvement. The Safe Speed Test correlations were higher for the at-fault and cost of accident criteria. The Accident Causation Test, however, was not significantly related to these driving performance criteria.

Table 1. Correlations between the Tacit Knowledge Test measures and Accident Involvement

| Test Measure | Accident Criteria | | | Cognitive |
|---|---|---|---|---|
| | Total | At Fault | Cost | Aptitude |
| **Overall Mean Measures** | | | | |
| Safe Speed Knowledge | -.05 | -.17*** | -.14 | .18*** |
| Accident Causation | -.02 | -.05 | -.04 | .09 |
| Slow Speed Orientation | .04 | .08 | .16* | -.31** |
| Cognitive Aptitude | .04 | .03 | .00 | -- |
| **Safe Speed Knowledge Test** | | | | |
| First-Order Factors: | | | | |
| Emotional | -.10* | -.19*** | -.16* | .11* |
| Dry Weather Environment | -.01 | -.10* | -.02 | .31*** |
| Precipitation Environment | -.06 | -.14** | -.17* | .11* |
| Second-Order/ Safe Speed Factor | -.08 | -.18*** | -.15* | .20*** |
| **Accident Causation Test** | | | | |
| First-Order Factors: | | | | |
| Weather & Age | -.08 | -.11* | -.09 | .03 |
| Alcohol | .13* | .11* | -.04 | -.04 |
| Intersections | .01 | -.04 | -.06 | .09 |
| Second-Order/Accident Causation Factor | -.01 | -.04 | -.06 | .05 |

*p<.05, **p<.01, ***p<.001. Tacit knowledge scores were "reflected" so superior performance would correlate positively with conventional knowledge tests and negatively with the accident criteria. Hypotheses involving the accident criteria are supported by negative values.

Because accidents are rare events and difficult to predict, odds ratios provide an alternate perspective on the magnitude of the relationship between performance on the Safe Speed Knowledge Test and accident involvement. These analyses show that compared to individuals scoring one standard deviation unit above the mean (high scoring individuals):

1. individuals scoring one standard deviation below the mean (low scoring) on the Safe Speed Knowledge Test were involved in five times as many at-fault accidents and had accidents that cost 124% as much per accident,
2. individuals scoring within one SD of the mean (average scoring) were involved in 2.3 times as many at fault accidents and had accidents that cost 54% as much per accident.

Slow Speed Orientation. Although we designed the Safe Speed Test to be scored using the consensual procedure, several scientists noted that a participant could indicate that a driver should slow down substantially for most or all of the Safe Speed items. To explore the possibility that drivers with a slow-speed orientation would be involved in fewer accidents, we computed the mean decrease in speed by averaging over the 14 Safe Speed Test item responses for each individual. This variable is based on the actual responses as opposed to the distance scores, and higher values indicate a more extreme slow-speed orientation. Contrary to expectation, "Slow Speed Orientation" correlated positively with the accident criteria, although only the correlation with cost was statistically significant, i.e. slow oriented individuals had more expensive accidents ($r=.16$, $p<.05$) and more accidents ($r=.08$, ns).

Factor Analysis: Overview. To better understand the constructs measured by the two tests, we factored the 14 distance-items for each scale. We then correlated the factor scores with the accident criteria. The factor analysis procedure was based on recommendations in Jensen and Weng (1994). The analyses for each scale:

1. Used the SPSS principal axis factoring and the oblimin procedures to extract and rotate first-order factors, and calculate first-order factor scores.
2. Used the principal components procedure to extract a single second-order factor, and calculate the second-order factor scores.
3. Correlated the first and second-order factor scores with the accident criteria and the cognitive aptitude scores.

Factor Analysis: Safe Speed Knowledge. The most interesting results were obtained by analyzing the distance-items for the Safe Speed Knowledge test. Four eigenvalues were extracted that were greater than 1.0 and we specified two, three and four factor solutions. In each analysis, one of the first-order factors was defined by the internal/emotional items and the remaining factors were defined by clusters of environmental items.

The pattern matrix obtained for the three-factor solution is representative of the findings and is presented in Table 2. The first factor is defined by items that tend to correspond to

Table 2. Factor structure of the Safe Speed Knowledge items

| Test Items | Factor Loadings | | |
|---|---|---|---|
| | Emotional | Dry-Weather | Precipitation |
| Defining items for the Emotional factor: | | | |
| Upset with family over finances (13) | .75 | -.02 | .02 |
| Sick with a head cold (14) | .73 | -.11 | -.06 |
| Slightly worn tires (12) | .55 | .03 | -.03 |
| Stressed over work problems(5) | .46 | .05 | .18 |
| Light Traffic & Hilly (11) | .45 | .17 | .07 |
| Moderately Heavy Traffic (6) | .26 | .17 | .17 |
| Gravel & light traffic (7) | .26 | .11 | .25 |
| Defining items for the Dry-Weather Environment factor: | | | |
| Clear & light traffic (2) | -.04 | .94 | -.14 |
| Clear & Breezy (8) | -.15 | .69 | .13 |
| Dry & Midnight (4) | .19 | .61 | -.01 |
| Defining items for the Precipitation-Environment factor: | | | |
| Light rain & curves (9) | -.04 | -.10 | .73 |
| Angry & Light Rain (10) | .20 | -.12 | .48 |
| Snow & no traffic (3) | .05 | .02 | .41 |
| Snow & heavy traffic (1) | -.04 | .14 | .31 |
| | Factor Correlations & Second Order Loadings | | |
| First Order Factors | | | |
| Emotional | 1.00 | .25 | .54 |
| Dry Weather Environment | | 1.00 | .30 |
| Precipitation Environment | | | 1.00 |
| Second Order Factor: General Safe Speed Knowledge | .87 | .61 | .89 |

internal states, and this factor is interpreted as an Emotional Knowledge factor; the remaining two factors correspond to the environmental conditions, the Dry Weather and the Precipitation factors. The one item that referenced an internal state and an external condition, "anger and light rain," primarily loaded on the Precipitation factor, .48, but had a secondary loading on the Emotional Knowledge factor, .20. The loadings of the first-order factors on the second-order factor are also contained in Table 2.

The correlations between the Safe Speed factor scores and the accident criteria are reported in the middle section of Table 1. As might be expected, we observed higher correlations between the second-order factor scores and the criteria than between the simpler "mean distance" variable and the criteria. The tabled values indicate that the highest first-order factor correlations were obtained between the Emotional Knowledge factor and the accident criteria.

Factor Analysis: Accident Causation Knowledge. The accident causation items were also factored, but the results were less clear than those obtained for the Safe Speed items. While five eigenvalues were greater than 1.0, a three factor solution was selected for presentation based on the scree plot. The three factor solution is summarized by the pattern matrix in Table 3. The second-order loadings are contained in Table 3.

Table 3. Factor structure of the Accident Causation Knowledge items

| Test Items | Factor Loadings | | |
|---|---|---|---|
| | Weather | Alcohol | Intersections |
| Defining items for the Weather & Age: | | | |
| Snowy Conditions (12) | .59 | .09 | -.09 |
| Rainy Conditions (7) | .36 | -.01 | .18 |
| Middle Aged Drivers (8) | .36 | -.04 | -.01 |
| Young Drivers (11) | .35 | -.04 | .02 |
| Old Drivers (13) | .26 | .03 | .11 |
| Stressed Drivers (9) | .25 | .01 | .13 |
| Sunny Weather (10) | .21 | .15 | .02 |
| Defining items for the Alcohol factor: | | | |
| Drunk Drivers (2) | .25 | .62 | -.07 |
| Windy Roads (1) | -.13 | .32 | .24 |
| Defining items for the Intersections factor: | | | |
| Traffic Light Intersections (14) | .23 | -.30 | .50 |
| Stop sign Intersections (5) | .07 | -.10 | .46 |
| Interstate Highways (4) | .08 | .13 | .37 |
| Parking Lots (6) | .00 | .00 | .34 |
| Excessive Speed (3) | .01 | .11 | .30 |

| | Factor Correlations & Second-Order Loadings | | |
|---|---|---|---|
| First Order Factors | | | |
| Weather & Age | 1.00 | .09 | .42 |
| Alcohol | | 1.00 | .18 |
| Intersections | | | 1.00 |
| Second Order Factor: Accident Causation Knowledge | .88 | .47 | .87 |

The correlations between the accident criteria and the Accident Causation factor scores are reported in the final section of Table 1. While these values are lower and less consistent than those obtained for the Safe Speed Knowledge items, the correlations suggest some relationship between accident-causation knowledge and traffic accident involvement.

Cognitive Aptitude. Table 1 also reports correlations quantifying the relationships among cognitive aptitude, tacit driving knowledge and accident involvement. Low to moderate correlations (.11 to .31) between cognitive aptitude and the tacit knowledge factors are reported, and the only moderate correlation, .31, involved the Safe Speed factor that was least related to the accident criteria. Near-zero correlations were obtained between the accident criteria and cognitive aptitude scores.

Standard Psychological & Situational Measures: Correlations

The relationship between accident involvement and the stable characteristics was evaluated by correlating the stable measures with the accident criteria across individuals. The criteria included the rate variables (i.e., the number of at-fault accidents per day and the number of accidents per day) and the overall cost of accidents per individual. These analyses required individuals to be treated as cases and can be conceptualized as standard validation exercise.

It was not sensible to adopt a standard validation procedure to evaluate the impact of transient variables on accident criteria because these variables were primarily hypothesized to relate to individual traffic crashes as opposed to long-term accident rates. The transient variables were analyzed by transforming the data files so that accidents were defined as cases with the transient and stable variables as fields. The transient variables (and some stable measures) were then correlated across accidents with criteria such as "At-Fault Status" and "Crash Cost".

Stable Characteristic. Table 4 lists the correlations obtained between the standard psychological measures and the accident criteria; these values are based on the larger sample of 551 participants. Significant correlations were obtained for measures of dependability, approval for discipline, polyphasic behavior (a tendency to perform multiple tasks), spatial aptitude, and moving violations (number of tickets). As is frequently observed in accident research, most of the correlations were low and the most substantial correlation in Table 4 was obtained for the moving violation variable (number traffic tickets – not reflected) in the expected direction, .23. Substantial correlations are uncommon in accident research because accidents are rare events and are determined by multiple factors.

Table 4. Correlations between stable measures and accident criteria.

| Stable Measures | Total At fault Accidents Per Day | Total Accidents Per Day | Total Cost of Accidents |
|---|---|---|---|
| General Cognitive Aptitude Test | | | |
| AFQT | .03 | .04 | .00 |
| Spatial Reasoning Tests | | | |
| Map | .00 | .05 | -.09 |
| Maze | .04 | .09* | -.03 |
| Object Rotation | .06 | .10* | .00 |
| Orientation | .01 | .01 | -.13 |
| Figural Reasoning | .02 | .06 | -.08 |
| Channel Capacity Tests | | | |
| Waypoint Channel Capacity | -.04 | -.02 | -.09 |
| Waypoint CC Norms | -.05 | -.02 | -.07 |
| Waypoint Risk Group | -.02 | .00 | .03 |
| AIM Personality Measures | | | |
| Dependability | -.08 | -.10* | -.01 |
| Dominance | .00 | .00 | -.05 |
| Adjustment | .05 | .05 | -.02 |
| Work Orientation | -.02 | .00 | .00 |
| Agreeableness | -.08 | -.02 | .02 |
| Physical Condition | .00 | .00 | -.02 |
| Social Desirability | .02 | -.03 | -.04 |

Table 4 (continued)

| Standard Variable | Total At fault Accidents Per Day | Total Accidents Per Day | Total Cost of Accidents |
|---|---|---|---|
| Additional Personality Measures/Tendencies | | | |
| Impatience | .05 | .02 | -.08 |
| Irritability | -.01 | .00 | -.04 |
| Polyphasic Behavior | -.10* | -.05 | .00 |
| Type A Indicators | -.03 | -.03 | -.09 |
| Internal Locus of control | -.04 | -.05 | .01 |
| External Locus of Control | .04 | .04 | -.09 |
| Restless | .07 | .04 | -.03 |
| Risk Taker | .00 | .01 | -.06 |
| Lively | .03 | -.01 | -.03 |
| Impulsive | .04 | .04 | .04 |
| Approve Discipline | -.11* | -.08 | .06 |
| Driving Record | | | |
| Number of Tickets | .22** | .23** | .04 |

Note: *p <.05. **p<.01.

Table 5. Correlations between self-report situational measures and accident criteria.

| Situational measures | At-Fault Status | Crash Cost | At-fault Rate | Accident Rate |
|---|---|---|---|---|
| Tacit driving knowledge test scales: | | | | |
| Safe speed | -.22*** | -.12 | -.38*** | -.30*** |
| Accident causation | -.09 | .00 | -.38*** | -.40*** |
| Emotional state prior to accident: | | | | |
| Stressed versus calm | .22*** | -.07 | .20** | .15* |
| Heightened stress due to life events (divorce, illness…) | .23*** | .05 | .00 | .10 |
| Fatigued at time of accident | .16* | .02 | .06 | .04 |
| Insufficient sleep night before accident | .20*** | .08 | .26*** | .24*** |
| Passengers disturbing driver | .17** | .29*** | .04 | -.02 |
| Number of passengers | -.02 | .07 | .13* | .10 |
| Alcohol and drug involvement: | | | | |
| Medicine /drug use | .22*** | -.02 | .52*** | .44*** |
| Alcohol use | .13* | .16* | .44*** | .38*** |
| Affected by alcohol | .20*** | .17** | .50*** | .45*** |
| Alcohol contributed | .18** | -.02 | .53*** | .48*** |
| Driving conditions & speed: | | | | |
| Speed of traffic | .02 | .12 | -.12 | -.09 |
| Driver speed vs. others | -.06 | -.07 | -.11 | -.06 |
| Driver speed vs. limit | .13 | -.04 | .16* | .11 |
| Amount of traffic | .01 | .07 | -.16** | -.13* |
| Weekend night hour | -.01 | .12* | .13* | .12* |
| Road condition contributed | .14* | -.04 | -.02 | -.09 |
| Vehicle condition contributed | .07 | .14* | .09 | .08 |
| Seatbelt use | -.01 | -.07 | -.27*** | -.25*** |

Note: *p <.10. **p<.05. ***p<.001

Transient Variables. Table 5 reports correlations between the transient / situational measures and the accident criteria. These correlations are not strictly comparable to those reported in Tables 1 and 4 because they were calculated by treating accidents as cases instead of individuals. However, these correlations are useful for identifying transient or situational events that relate to accident involvement.

The correlations between the at-fault and cost criteria (cf. Table 5 columns 1 and 2) with the transient/situational variables are relatively easy to understand. For example, individuals reporting that they were being distracted by passengers were more likely to be at-fault, r=.17, and tended to be involved in more expensive accidents, r=.29.

The correlations between the situational variables and the accident rate criteria (cf. Table 5 columns 3 and 4) are more difficult to explain. These values indicate the extent to which the situational variables were important in predicting accident rates for individuals who had been involved traffic crashes. For example, the correlation between the Alcohol variables with the At-Fault Rate criterion are substantial (up to .53) and may indicate that individuals who are involved in greater numbers of at-fault accidents tend to use alcohol more often.

To allow comparison of the transient and tacit driving knowledge measures, the tacit knowledge scores were treated as transient variables and the corresponding correlations are also reported in Table 5. In Table 5, all the statistically significant correlations were in the expected direction. Many of the more substantial correlations involve transient variables that relate to the emotional or internal state of the driver in the time immediately prior to the accident, and these findings obviously complement the results obtained for the emotional knowledge items on the Safe Speed test.

Incremental Validity Associated With the Safe Speed Knowledge Test

Multiple regressions were computed to assess the incremental value of the Safe Speed Knowledge scales over the conventional stable measures. We first selected measures corresponding to the significant correlations reported in Table 4 and included those measures with the Safe Speed factor scores as predictors in a SPSS stepwise regression procedure. The procedure was repeated for each of the three criteria listed in Table 4. To utilize the full sample, we used the pairwise option to handle missing data. The regressions indicated that the Safe Speed factor scores added to the prediction of both the cost and at-fault accident rate criteria, and the results are summarized in Table 6.

We also computed stepwise multiple regression equations using the stable and transient variables, for which significant correlations are reported in Table 5 against the At-Fault Status criterion. The results are reported in Table 6 and indicate that the Tacit Driving Knowledge measures add validity to the prediction of At-Fault Status.

Table 6. Stepwise regressions predicting accident criteria using tacit and conventional measures.

| Variables In Equation | Beta | Sig | Multiple-R | Shrunken-R | Model Sig |
|---|---|---|---|---|---|
| | | At-Fault Accident Rate[1] | | | |
| Tickets | .21 | .000 | .31 | .30 | .000 |
| Safe Speed – general factor | -.16 | .002 | | | |
| Support for Discipline | -.12 | .015 | | | |
| Polyphasic Tendency | -.11 | .036 | | | |
| | | Total Accident Rate[1] | | | |
| Tickets | .22 | .000 | .22 | .21 | .000 |
| | | Total Accident Cost[1] | | | |
| Safe Speed–Precipitation Factor | -.17 | .03 | .17 | .15 | .03 |
| | | At-Fault Status Per Accident[2] | | | |
| Heightened stress due to life event | .23 | .001 | .42 | .39 | .000 |
| Tacit Knowledge - Safe Speed | -.17 | .018 | | | |
| Medicine/drug use | .20 | .006 | | | |
| Road Conditions | .14 | .042 | | | |
| Passengers Disturbing Driver | .14 | .045 | | | |

Notes: Pairwise deletion used for missing data.

[1]The independent variable set contained the Safe Speed Knowledge Test factors, Number of Tickets, AIM Dependability, Maze, and Object Rotation measures.

[2] The independent variable set included all variables listed in Table 5 as being significantly correlated with the At-Fault Status criterion.

Tacit Driving Knowledge Tests: Aggregate Analyses

While the conventional scales and measures primarily provide a means to predict accident involvement and severity, the data collected using the Safe Speed and Accident Causation scales can also be analyzed at the aggregate level. From this perspective, the scales allow exploration of possible misconceptions regarding driver safety. We felt that these analyses might lead to important insights and provide input for safety messages. This expectation was bolstered by the correlations that demonstrate the relationship between tacit driving knowledge and the accident criteria.

Safe Speed Knowledge Items. Table 7 lists the means and standard deviations for the responses for the 14 Safe Speed Knowledge test items. These means constituted the scoring key and therefore provided the basis for the results obtained with this scale. Viewed from a scoring perspective, these means indicate the extent to which drivers should be encouraged to modify their speed or change their driving-styles in response to these types of driving hazards.

Table 7. Safe Speed Knowledge Test item response distributions.

| Test Items | Descriptive Statistics | | |
|---|---|---|---|
| | Mean | Standard Deviation | Percentage Indicating No Decrease in Speed |
| Internal / Emotional Items: | | | |
| Upset with family over finances (13) | 8.39 | 5.30 | 16 |
| Sick with a head cold (14) | 8.50 | 5.08 | 13 |
| Stressed over work problems (5) | 7.61 | 4.90 | 18 |
| Mixed Item: | | | |
| Angry & Light Rain (10) | 10.59 | 4.43 | 3 |
| Environmental Items: | | | |
| Slightly worn tires (12) | 7.62 | 4.92 | 14 |
| Light Traffic & Hilly (11) | 6.17 | 4.28 | 20 |
| Moderately Heavy Traffic (6) | 7.70 | 4.17 | 8 |
| Gravel & light traffic (7) | 7.77 | 4.02 | 7 |
| Clear & light traffic (2) | 1.50 | 3.19 | 78 |
| Clear & Breezy (8) | 2.77 | 3.52 | 49 |
| Dry & Midnight (4) | 4.52 | 3.79 | 28 |
| Light rain & curves (9) | 10.40 | 4.07 | 1 |
| Snow & no traffic (3) | 11.17 | 4.11 | 2 |
| Snow & heavy traffic (1) | 14.81 | 4.01 | 0 |

Table 7 also lists the proportion of respondents who indicated that drivers should not slow down for each item. A disturbing finding is that a substantial percentage of the respondents (up to 18 percent) indicated that internal states, e.g., illness and stress, did not constitute cause to modify speed.

Accident Causation Items. The Accident Causation items required individuals to estimate the percentage of major accidents involving each of the 14 separate conditions. Although it might seem unreasonable, an individual could indicate that 100% of major accidents (i.e., all) involved any of the 14 conditions. Because scores from the Accident Causation Test

did not correlate significantly with the accident criteria, we did not present the response distributions for most of the items.

However, the response distribution for the item that required participants to estimate the percent of major accidents involving "drunk drivers" gave important insight and is presented in Figure 3. The response distribution indicates that 15 percent of the participants believed that all major accidents involve alcohol, and that 52 percent believed that over three-quarters of all major accidents involve alcohol. For comparison, U.S. Department of Transportation statistics (1998b) estimate that four-tenths of fatalities involve alcohol, and the proportion decreases for less serious accidents.

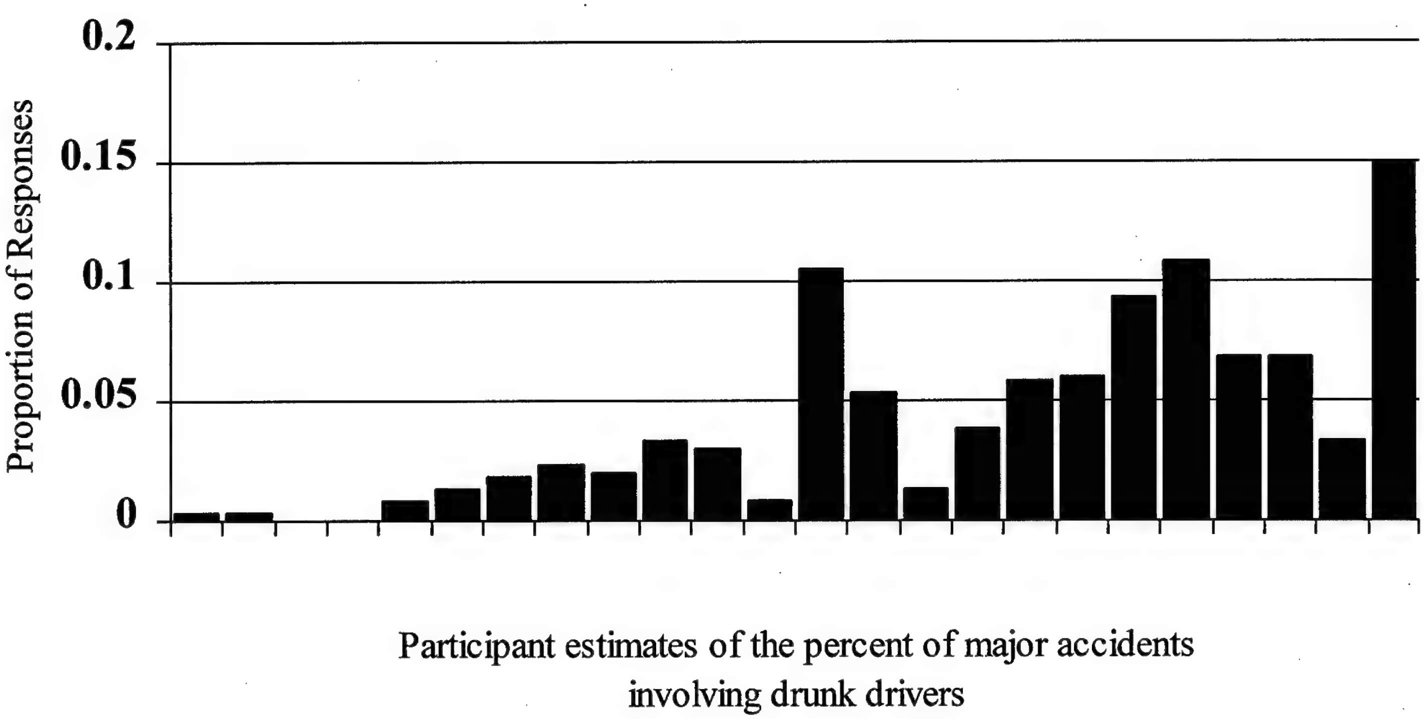


Figure 3. Perceived involvement of alcohol in major accidents

## Discussion

At the outset of this project we were unable to locate driving knowledge tests developed for the general population that had been linked to accident risk[1]. We were also perplexed by the

[1] Driving knowledge tests developed for license certification represent a different class of scales because they assess a minimal level of competency (cf. Veling, 1982).

fact that high school driver education programs, which are designed to provide practical driving knowledge and experience to new drivers, have at best only a minor impact on accident involvement (Evans, 1991; Robertson & Zador, 1978; Lund, Williams & Zador, 1986). This lack of relationship is surprising because individual differences in many if not most performance areas can be associated with some knowledge domain. Instead of assuming that driving performance constitutes a special "knowledge-less" domain, we suspected that conventional knowledge tests have not adequately corresponded to domains that differentiate high and low risk drivers.

We expected that we could link tacit driving knowledge and accident risk because accident risk decreases with driving experience, and it seemed intuitively reasonable that a link between experience and accident risk should imply associations with tacit driving knowledge. The correlations and the odds ratios obtained for the Safe Speed Knowledge test demonstrate the importance and relevance of this type of knowledge to driver safety.

We were pleasantly surprised by the magnitude of the correlations obtained between the accident criteria and the emotional knowledge factor scores and items. When interpreting the correlations for the emotional knowledge items and factor scores, it is important to realize that these results are highly consistent with the correlations obtained between the accident criteria and the transient variables corresponding to a driver's emotional or internal state immediately prior to an accident. Both sets of predictors demonstrate the importance of a driver's emotional or internal state to accident involvement.

It seems reasonable to believe that stressful events act as predisposing factors for accident involvement. Emotional intelligence, and in particular emotional knowledge about driving safety, may then mitigate the adverse effect of the stressful event.

## Theoretical Issues

Tacit Knowledge Criteria. The intent of these scales was to measure tacit driving knowledge with the expectation that this construct might be useful in understanding traffic accidents and improving driving safety. Our approach capitalized on theoretical developments regarding tacit knowledge (Sternberg et al., in press) and emotional intelligence (Mayer, Caruso, & Salovey, in press).

Tacit knowledge is conceptualized as knowledge (1) grounded in experience, (2) intimately related to action, and (3) not well supported by formal training and doctrine (Sternberg et al, in press). While most applications involving tacit knowledge have focused on understanding areas of professional expertise, it is reasonable that driving performance would be associated with some tacit knowledge domain.

We believe the domains tapped by these scales meet the above tacit knowledge criteria. First, performance on these measures seems to reflect experience (criterion # 1). It is reasonable to maintain that because driver education and certification programs have not been designed to

emphasize this type of information, the primary mode available to most individuals to acquire this knowledge is experience.

Second, awareness of factors that impact driving safety should allow individuals to more appropriately utilize their resources and decrease their accident risk. It follows that this type of knowledge is, or should be, intimately related to driving decisions (criterion # 2). While a retrospective design can not demonstrate causation, the correlations and odds ratios between performance on these scales and accident involvement suggests that appreciation of the impact of driving conditions on safety substantially lowers (improves) accident risk. One concern we had with using a retrospective design was that individuals who had accidents might become more cognizant of driving hazards and provide more optimal responses on the tacit driving knowledge scales. However, this tendency would lower correlations obtained using a retrospective design; therefore, the tacit knowledge correlations may underestimate those that would be obtained using a predictive design.

Third, while formal training programs could be developed to identify conditions under which and the extent to which drivers should modify driving speed or style, we do not know of any ongoing effort to identify this knowledge or develop the corresponding instruction. In fact one reason for adopting the consensual scoring procedure was that a formal knowledge base containing this type of information could not be located. It follows that without the relevant knowledge base, developing a formal training package is not possible (criterion # 3).

While performance on tacit knowledge tests could help support personnel selection, the values used to score the tests may be much more valuable for driver training and safety messages. This is because the values computed to score the tests provide insights into the factors that lower-risk drivers consider. By specifying these factors, this information could be explicitly taught to inexperienced or higher-risk drivers.

Emotional Knowledge. While the answers to the environmental items on the Safe Speed Knowledge test could be obtained through simulations, it seems difficult to identify the optimal responses for the emotional items using other than a consensual procedure. It was unexpected that the factor scores corresponding to the internal/emotional events correlated as highly with the accident criteria as the more mundane environmental items and their corresponding factors. These emotional items and their correlations (1) underscore the adaptive advantage associated with understanding one's emotions and their impact on safety and (2) suggest value in viewing emotional intelligence from a tacit knowledge perspective.

In hindsight it might seem obvious that individuals who are more appreciative of the impact of their emotions on driving performance should be less likely to be involved in accidents. This expectation is especially reasonable because the correlations for the transient variables that relate to a driver's emotional state immediately preceding an accident (e.g., being stressed as opposed to calm or having experienced a stressful life event) are significant and in a consistent direction. However, these relationships had not been well documented in the past and the magnitudes of the effects are surprisingly strong. The utility of these emotional/internal items in predicting accident criteria demonstrates the value of the conceptualization of emotional

intelligence as a set of abilities and corresponding knowledge (Mayer, Caruso, Salovey, in press).

It is reasonable to speculate that individuals scoring low on emotional intelligence instruments are disadvantaged in several respects regarding driver safety. First and most obviously, these individuals are less aware of the importance of moderating their driving styles during periods of stress or emotional extremes and are more likely to suffer consequences. Second, they may lack emotional coping mechanisms to avoid or minimize the impact of adverse or unusual events. Therefore these drivers may be more frequently distressed, or distressed to a greater extent. Finally, they may be less likely to be influenced by individuals who are more aware of the potential effects of emotional states on driver safety and whose advice might improve safety.

Tacit Driving Knowledge in Relation to Cognitive Aptitude and Personality Traits. The correlations among tacit driving knowledge, cognitive aptitude and the accident criteria are interesting to the extent that tacit driving knowledge, and in particular emotional/internal knowledge, correlated with accident involvement while being nearly independent of cognitive aptitude (Tables 1 & 4). These correlations and the regression analyses (Table 6) indicate that emotional intelligence is also distinct from the other stable personality traits we measured. We had planned to determine if tacit driving knowledge could add incremental validity to cognitive aptitude against the accident criteria; however, this was unnecessary since the correlations between the cognitive aptitude and accident criteria were negligible.

Therefore the tacit driving knowledge scales appear to tap a dimension that is related to general cognitive aptitude and conventional measures of personality while still being related to accident involvement, even though those conventional measures are not related to accident involvement. It is important that the factor score correlations suggest that the substantial relationships obtained for the tacit driving knowledge tests would not have materialized had the emotional items not been included in the scales. While low correlations between cognitive aptitude and accident involvement are common in driver research, it is difficult to rationalize a lack of a relationship between accident involvement and cognitive aptitude to the extent that driving qualifies as a complex cognitive task.

If emotional intelligence is considered a separate type of intelligence, then it is easier to understand a lack of a relationship with conventional measures of cognitive aptitude and this perspective lends credibility to theories of emotional intelligence. However, it is important to acknowledge that U.S. Army populations suffer from range restriction on cognitive aptitude measures because enlistment policy requires recruits to score in the upper 70 percent on a cognitive aptitude test (cf. Office of the Assistant Secretary of Defense, 1996). Therefore higher correlations might be obtained for more representative populations.

Within this data base most of the correlations between cognitive aptitude and the Safe Speed factor scores tended to be low, .11 to .20. The only moderate factor correlation, .32, involved the only Safe Speed Knowledge Test factor that did not correlate with any accident criterion. These values may reflect difficulty in learning these relationships because exposure to

tacit driving knowledge, especially emotionally related knowledge, may be quite variable and stochastic. This type of variability would decrease the magnitude of the correlation between cognitive aptitude and tacit knowledge and might explain the correlations we obtained. This explanation suggests that a higher correlation between cognitive aptitude and tacit driving knowledge would be obtained if this knowledge were explicitly taught like an academic subject.

Moderation in Some Things. We were surprised by the response distributions for the emotional items because up to 18% of the sample completely discounted emotional or internal information when estimating safe speeds. From a driving safety perspective, it is disturbing that over one-sixth of our drivers believe that moderation in speed is not needed during periods of stress or illness. On the positive side, this percentage suggests that driving safety could be substantially improved by conveying information regarding factors that should be considered when driving.

It is important to emphasize that better drivers provided only moderate adjustments in driving style, i.e., speed, in response to the emotional and the less-severe environmental conditions, and these adjustments are reported in Table 7. In other words, those individuals who provided more extreme responses, i.e., slow down either excessively or very little, tended to have more and worse accidents. However, the results do not contradict the expectation that drivers should substantially change their driving style in response to severe conditions, e.g., "snow & heavy traffic." The data indicate that lower risk drivers are more likely to be aware of when and how much to change their driving style, rather than to believe individuals should react excessively to many conditions.

## Practical Implications

While the correlations obtained for the tacit driving knowledge measures are modest, these correlations compare favorably to those obtained for the stable personality traits and were consistent with the correlations obtained for the transient/situational measures. In this context it is important to appreciate that most traits are difficult to modify because they are stable. The tacit knowledge test data are important because they identify dimensions that differentiate high and low risk drivers and provide content for public education and safety messages to improve safety.

These analyses suggest that drivers should be encouraged to adjust their driving styles in a manner that is proportional to the severity of both environmental events and internal/emotional conditions. While identifying these events and conditions more methodically would provide a more valuable knowledge base, an approximation can be based on the aggregate analyses computed for the Safe Speed Knowledge Test data. At a minimum, drivers need to be informed that they should modify their driving styles under adverse internal/emotional conditions, e.g., during periods of stress, illness or fatigue. The fact that one-sixth of the participants did not identify emotional or internal states as cause to modify speed highlights the importance of conveying this information.

While teaching individuals that emotional and internal events are associated with accident involvement, it is reasonable that some individuals will have trouble identifying these internal/emotional states and may benefit from learning to identify events that elicit these states. Therefore, widely conveying that accident risk is increased by stressful events such as relational contentions or financial troubles might substantially enhance public safety. A variation on this theme is to encourage family and peers to be actively involved in helping drivers recognize and control the impact of their internal or emotional states on driving safety. Passengers should also be informed that a particularly inappropriate behavior is to intentionally disturb or stress a driver, (cf. Table 5 correlations involving the transient variable, "passenger distracting driver"). In addition to being sober, designated drivers should be calm, healthy and rested.

Drivers should be encouraged to drive with a level of moderation that is proportionate to ongoing conditions, environmental or emotional. While a more complete knowledge base is needed to develop a hierarchy to discriminate among moderately poor driving conditions, a classification of environmental conditions into a primitive hierarchy seems feasible and might be helpful for some individuals.

While it is well understood that alcohol is an important factor in accidents, the fact that some individuals identify alcohol as being involved in nearly all accidents was surprising and disturbing. Figure 3 shows that 15 percent of the sample believed alcohol was involved in all or nearly all major accidents and 52 percent believed alcohol was involved in over three-quarters of accidents. These perceptions contrast with Department of Transportation statistics (1998b), estimating that 40 percent of fatalities involve alcohol and thus implying that a majority of serious accidents (60 percent) do not. These perceptions may reflect the emphasis attached to alcohol in both public safety messages. While it seems beneficial that more drivers are becoming aware of the dangers associated with alcohol, this perception allows the possibility that some individuals will assume that they are safe to drive provided they have not consumed alcohol. While we are not suggesting that alcohol be de-emphasized, it is important to emphasize that other factors, including emotional/internal states and environmental conditions, can combine to precipitate accidents.

The recommendations we describe are consistent with the notion that higher-risk drivers could profit by using safe drivers as models for their own behavior. They are also consistent with the expectation that individuals are more likely to be involved in traffic crashes when under emotional or internal stress. From this perspective, the aggregate analyses provide a succinct summary of beliefs and attitudes distinguishing better drivers that could be taught to improve driving safety. It is reasonable to assume that many drivers would benefit from an effort to emphasize the importance of these factors.

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